UPDATE TO THE REPORT ON THE CONSERVATION STATUS OF *Arabis fecunda*, A CANDIDATE THREATENED SPECIES

Taxon name:	*Arabis fecunda* Rollins
Common name:	Sapphire rockcress
Family:	Brassicaceae (Cruciferae)
State where taxon occurs:	U.S.A., Montana
Current Federal status:	USFWS Notice of Review, Category 2
Recommended Federal status:	USFWS Notice of Review, Category 2
Author of update:	Lisa Ann Schassberger
Original date of report:	November 15, 1985
Date of most recent revision:	December 19, 1988

Individual to whom further information and comments should be sent:

J. Stephen Shelly
Montana Natural Heritage Program
State Library Building
1515 E. 6th Avenue
Helena, MT 59620

V. New Information

21. Record of revisions: 19 December 1988; Lisa Ann Schassberger; Topics: I.1.D.; I.2.B.1.b.; I.2.C.1.b.; I.3.E.; I.5.A.; I.5.B.1.; I.6.A.; I.6.B.1.b.; I.6.B.4.; I.6.B.5.; I.6.C.1.; I.6.C.6.; I.7.A.; I.7.B.1.; I.7.B.2.; I.7.C.1.: a., b., c., d., e., f., g., h., i., j., k., l.; I.7.D.4.; I.7.D.6.; I.8.C.2.b.; I.9.A.; I.9.B.; I.9.C.; I.9.D.; I.11.A.1.; II.12.; II.13.A.; II.13.B.1.; II.15.A.1.; II.15.A.2.; II.16; III.17.C.1.; III.17.D.; III.18.; Note: Within the text, numbers in parentheses following site names refer to the three-digit occurrence numbers, see Table 1 (p. 4).

I.1.D. **History and knowledge of taxon:** Since 1985, the sites in the foothills of the Sapphire Range in Ravalli County, Montana were resurveyed. Additional subpopulations were added to the three previously known sites and one new population was discovered. Additionally, eight new populations were located along the north and east flanks of the Pioneer Mountains, in Beaverhead and Silver Bow counties.

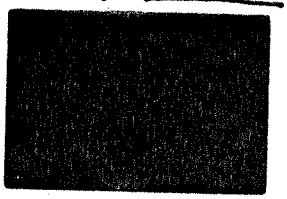
I.2.B.1.b. **Other current formal status recommendations:** The status of Arabis fecunda will be changed to "endangered throughout range" (global rank = G2) by the Montana Natural Heritage Program.

I.2.C.1.b. **Other current formal status recommendations:** The status of Arabis fecunda will be changed to "endangered" in Montana (state rank = S2) by the Montana Natural Heritage Program.

I.3.E. **Photographs and line drawings:** The color slides (p.2) are duplicates of those taken at the sites indicated. Additional slides of Arabis fecunda and its habitat are housed at the office of the Montana Natural Heritage Program, Helena, Montana.

I.5.A. **Geographical range:** With the addition of nine new sites, Arabis fecunda is now known to occur at elevations from 4,600-8,000 ft. A new site (1986) from the foothills of the Sapphire Range occurs along Birch Creek in Ravalli County, Montana. The sites discovered in 1988 occur along the Big Hole

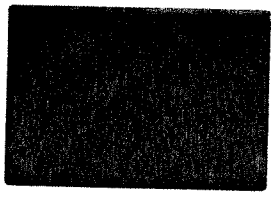
6/1988
Arabis fecunda



Vipond Park (011)

Lisa A. Schassberger

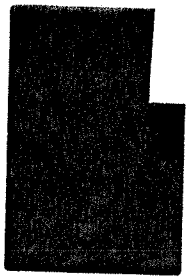
Arabis fecunda 6/1988



Mouth of Jerry Creek (007)

Lisa A. Schassberger

Arabis fecunda



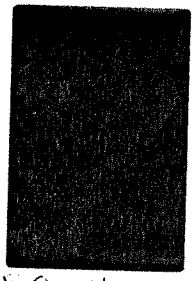
2

Lime Gulch (012)

Lisa A. Schassberger

Arabis fecunda 6/1988

Habitat

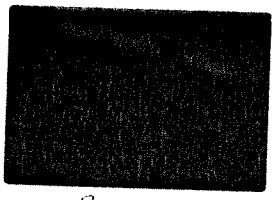


Mouth of Quartz Hill Gulch (006)

Lisa A. Schassberger

Arabis fecunda 6/1988

Habitat

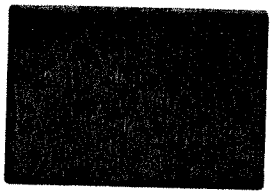


Mouth of Jerry Creek (007)

Lisa A. Schassberger

Arabis fecunda 6/1988

Habitat

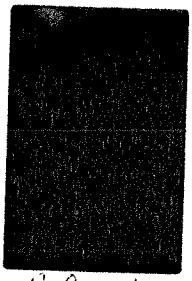


Lime Gulch, (012)

Lisa A. Schassberger

Arabis fecunda 6/1988

Habitat

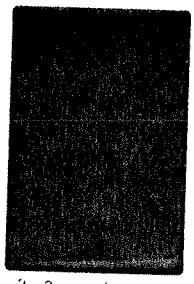


Mouth of Quartz Hill Gulch (006)

Lisa A. Schassberger

Arabis fecunda 6/1988

Habitat



Mouth of Quartz Hill Gulch (006)

Lisa A. Schassberger

River, and in several smaller drainages on the north and east flanks of the Pioneer Mountains, including: Jerry Creek, Quartz Hill Gulch, Canyon Creek and Birch Creek. These sites fall within Beaverhead and Silver Bow counties, Montana. The new sites along the flanks of the Pioneer Mountains extend the range of this species ca. 75 miles to the southeast. The global distribution for this species is shown on Map 1, p. 4.

I.5.B.1. **Populations currently known extant:**

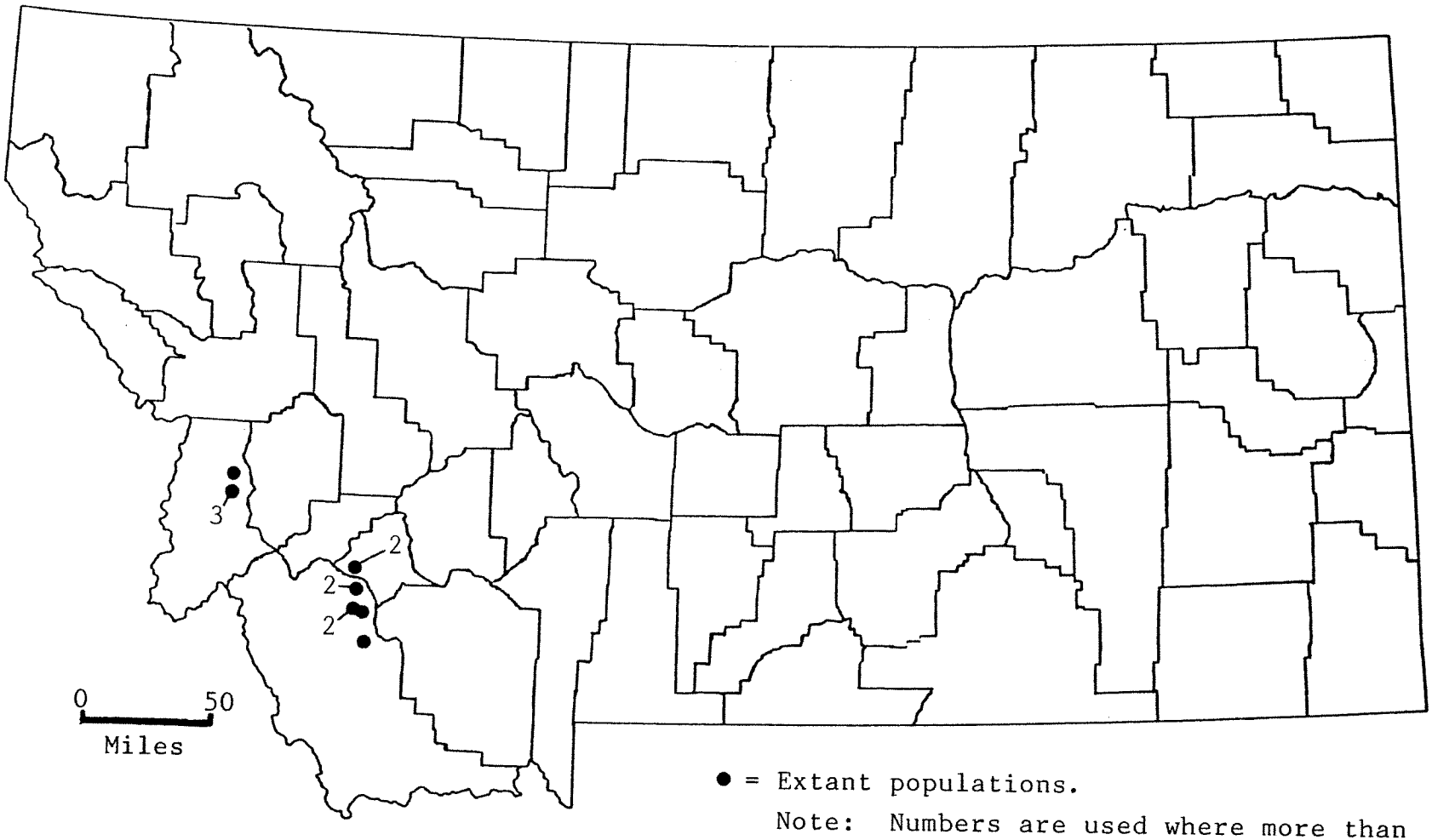
e. **Montana:** Populations are listed in Table 1, pp. 5-6; exact locations are provided on Maps 2-8, pp. 7-13. All twelve extant populations are included in these tables and maps, as additional subpopulation were discovered for the three sites described in the original report.

I.6.A. **Concise statement of general environment and habitat:** Populations are now known to occur up to 8,000 ft. in elevation.

I.6.B.1.b. **Regional macroclimate:** The long-term weather station nearest to the newly discovered populations in the Pioneer Mountains is at Divide, approximately 11 miles east of the sites, at 5,395 ft. in elevation. For the period from 1951-1980, the July mean temperature was 63.3 ^{o}F, the January mean was 19.1 ^{o}F, and the average annual precipitation was 12.39 in. (Department of Commerce, 1982).

I.6.B.4. **Physiographic and topographic characteristics:** The new sites along the flanks of the Pioneer Mountains occur on the Madison Limestone Formation, comprised of metamorphosed limestone and sandstones, and on the Threeforks Formation, comprised of grayish-brown argillaceous limestone (Richards and Pardee, 1925). These sites appear to be on substrates similar to those occupied by the Sapphire Range populations.

I.6.B.5. **Edaphic factors:** Arabis fecunda may be associated with cryptogamic soil crusts. The initial results of ongoing monitoring and ecological studies in Ravalli County are included in Appendix B, p. 36 (Lesica and



Map 1. Distribution of Arabis fecunda populations; the species is endemic to western Montana.

Table 1. Populations currently known extant.

Occurrence number: 001 Site name: CHARLEYS GULCH County: RAVALLI
Latitude: 461531 Longitude: 1140000 Elevation: 5000
Township & Range: 006N019W Sections: 20, W½, W½NE¼; 19, S½; 29, NW¼; 30, N½
USGS Quad: CORVALLIS, WILLOW MOUNTAIN Size: 7.5 minute series
Year of initial discovery: 1975
Date of most recent observation: 1988-06-01
Directions: CHARLEYS GULCH, WEST SLOPE OF SAPPHIRE RANGE, ALONG CHARLEYS GULCH ROAD CA. 1.1-2.1 MILES FROM JUNCTION WITH PAVED COUNTY ROAD; ALSO NORTH AND SOUTH OF GULCH.

Occurrence number: 002 Site name: SPRING GULCH County: RAVALLI
Latitude: 461452 Longitude: 1140109 Elevation: 4740
Township & Range: 006N019W Sections: 30, S½; 31, NE¼NW¼
USGS Quad: MOUNTAIN HOUSE Size: 7.5 minute series
Year of initial discovery: 1985
Date of most recent observation: 1988-06-01
Directions: SPRING GULCH, WEST SLOPE OF SAPPHIRE RANGE; AT JCT. OF HWYS. 269 & 380, 2.5 MI. E. TO WHERE 380 TURNS N.; E. 1.5 MI. TO CHARLEYS GULCH RD., 2 MI. TO CATTLEGUARD; SITES 1 MI. SW.

Occurrence number: 003 Site name: ROCK QUARRY GULCH County: RAVALLI
Latitude: 461358 Longitude: 1140137 Elevation: 4850
Township & Range: 006N019W Section: 31, NW¼SW¼
USGS Quad: MOUNTAIN HOUSE Size: 7.5 minute series
Year of initial discovery: 1985
Date of most recent observation: 1988-06-01
Directions: ROCK QUARRY GULCH; FROM JCT. OF HWYS. 269 & 380, GO 2.5 MI. E. TO CORNER WHERE 380 TURNS N.; GO E. 1.5 MI. TO CHARLEYS GULCH RD., & 2 MI. TO CATTLEGUARD; SITE IS 2 MILES SW.

Occurrence number: 004 Site name: BIRCH CREEK BLUFFS County: RAVALLI
Latitude: 462201 Longitude: 1135911 Elevation: 4700
Township & Range: 007N019W Sections: 16, NW¼; 17; 18, NE¼; 20, NE¼
USGS Quad: WILLOW MOUNTAIN,CORVALLIS Size: 7.5 minute series
Year of initial discovery: 1986
Date of most recent observation: 1988-06-01
Directions: WESTERN LOWER SLOPES OF SAPPHIRE MOUNTAINS, ALONG BIRCH CREEK AND TRIBUTARY NW. OF SCHOOLHOUSE BUTTE, CA. 7 AIR MILES ENE. OF CORVALLIS.

Occurrence number: 005 Site name: QUARTZ HILL County: BEAVERHEAD
Latitude: 454224 Longitude: 1125421 Elevation: 8000
Township & Range: 001S011W Section: 36, center
USGS Quad: VIPOND PARK (15) Size: 15 minute series
Year of initial discovery: 1986
Date of most recent observation: 1986-07-08
Directions: PIONEER MOUNTAINS, ECHO GULCH, SOUTHWEST BASE OF QUARTZ HILL.

Occurrence number: 006 Site name: MOUTH OF QUARTZ HILL GULCH County: BEAVERHEAD
Latitude: 454608 Longitude: 1125126 Elevation: 5780
Township & Range: 001S010W Sections: 8, E½; 5, SE¼; 17, NE¼
USGS Quad: DEWEY Size: 7.5 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-13
Directions: BEAVERHEAD NATIONAL FOREST. TRAVEL 0.25 MILE WEST OF DEWEY ON HIGHWAY 43, THEN SOUTH ON QUARTZ HILL GULCH, EAST AND WEST OF THE ROAD FOR 1.5 MILES.

Table 1. (cont.).

Occurrence number: 007 Site name: JERRY CREEK County: SILVER BOW
Latitude: 454718 Longitude: 1125402 Elevation: 5700
Township & Range: 001N010W Sections: 31, SW¼
001N011W 36, SE¼
USGS Quad: WISE RIVER Size: 7.5 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-07
Directions: CA. 1.5 MILES EAST OF WISE RIVER ON HIGHWAY 43, NE ON JERRY CREEK ROAD 0.3 MILE; HILLSIDES AND OUTCROPS EAST OF ROAD.

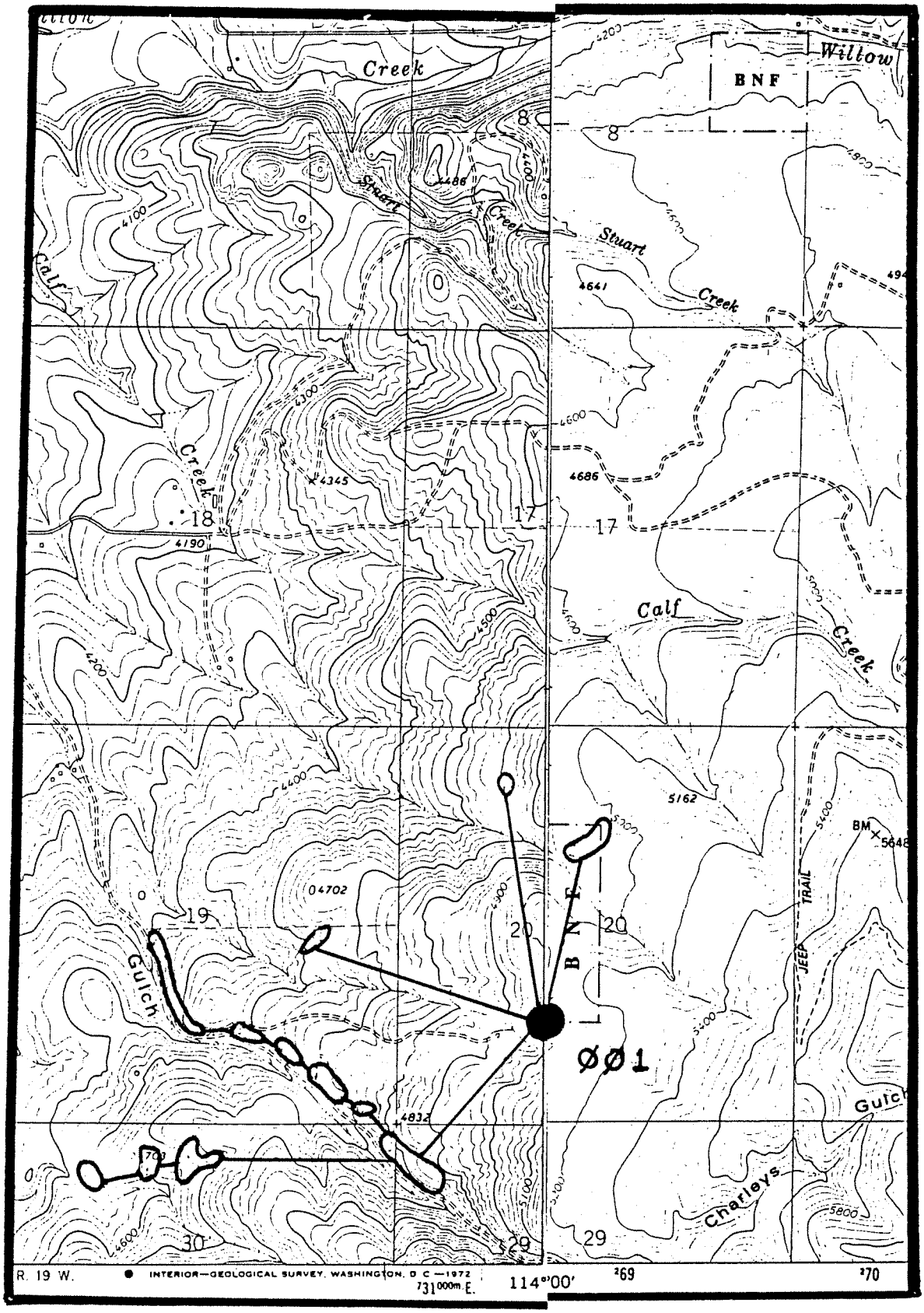
Occurrence number: 008 Site name: UPPER QUARTZ HILL GULCH County: BEAVERHEAD
Latitude: 454345 Longitude: 1125242 Elevation: 7500
Township & Range: 001S010W Sections: 19, SE¼; 20, SW¼; 29, SW¼; 30, SE¼
USGS Quad: VIPOND PARK Size: 15 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-07
Directions: CA. 3.75 MILES S. OF DEWEY ON QUARTZ HILL GULCH ROAD, CA. 0.2 MILE SW OF ROAD.

Occurrence number: 009 Site name: SPRING GULCH II County: BEAVERHEAD
Latitude: 454643 Longitude: 1125354 Elevation: 5600
Township & Range: 001S011W Section: 1, SE¼
USGS Quad: WISE RIVER Size: 7.5 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-07
Directions: CA. 2.2 MILES EAST OF WISE RIVER ON HIGHWAY 43. AT BEND, 0.20 MILE SOUTH OF ROAD ATOP STEEP CLIFFS.

Occurrence number: 010 Site name: BIG HOLE RIVER County: SILVER BOW
Latitude: 454709 Longitude: 1125230 Elevation: 5600
Township & Range: 001S010W Sections: 6, NE¼NE¼; 5, NW¼NW¼
USGS Quad: WISE RIVER, DEWEY Size: 7.5 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-07
Directions: 1.0 MILE WEST OF DEWEY ON HIGHWAY 43, 0.33 MILE NORTH OF ROAD ON THE NORTH SIDE OF BIG HOLE RIVER.

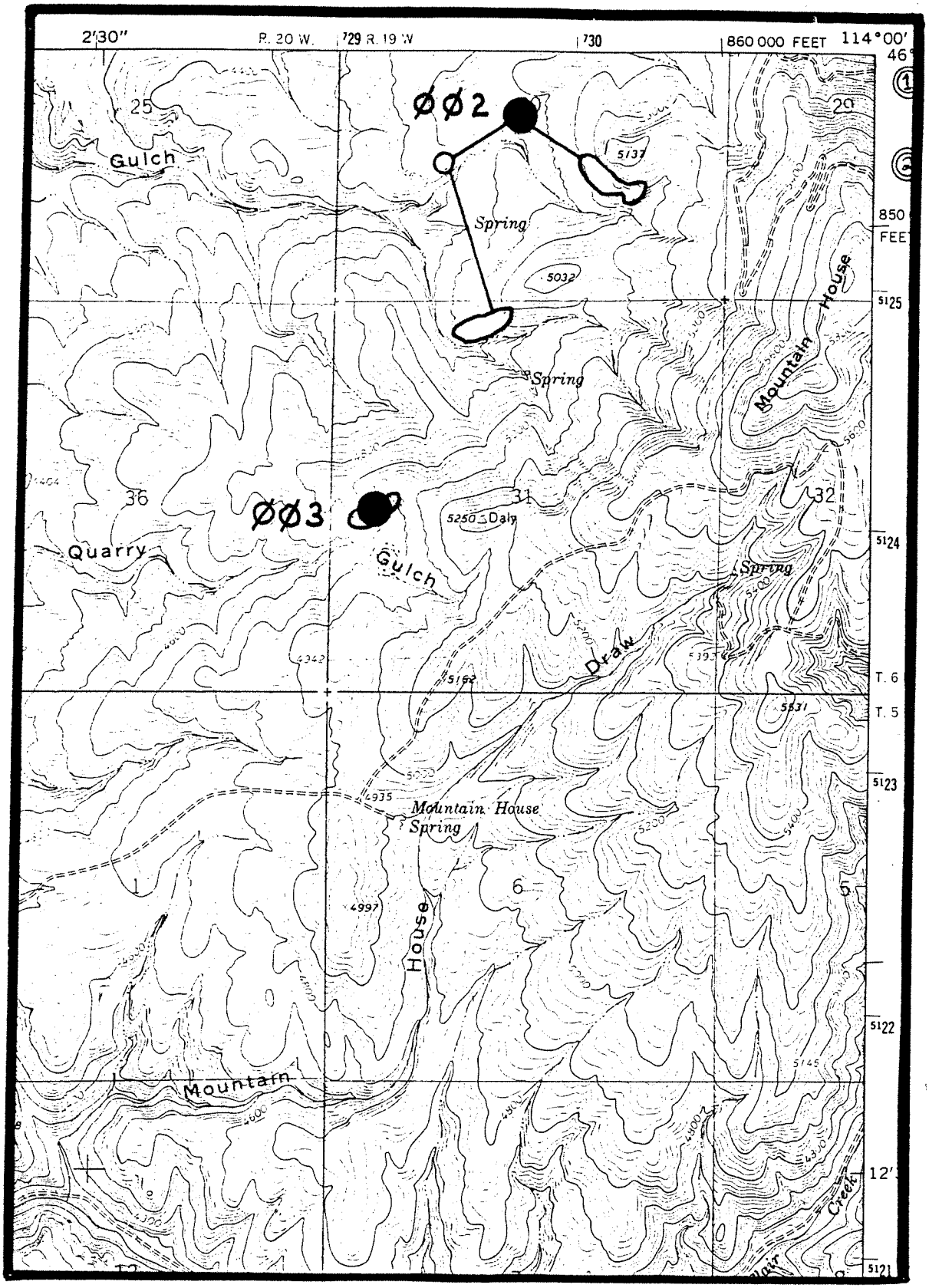
Occurrence number: 011 Site name: VIPOND PARK County: BEAVERHEAD
Latitude: 454059 Longitude: 1125213 Elevation: 7200
Township & Range: 002S010W Sections: 8, N½; 7, NE¼; 5, S½
USGS Quad: VIPOND PARK Size: 15 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-13
Directions: FROM MELROSE, CA. 12.5 MILES WEST, UP CANYON CREEK ROAD, AT CORNER OVERLOOKING KILNS.

Occurrence number: 012 Site name: LIME GULCH County: BEAVERHEAD
Latitude: 452352 Longitude: 1124844 Elevation: 6200
Township & Range: 005S010W Sections: 14, W½; 15, SE¼
USGS Quad: TWIN ADAMS MOUNTAIN Size: 7.5 minute series
Year of initial discovery: 1988
Date of most recent observation: 1988-06-15
Directions: 5 MILES WEST OF INTERSTATE-15, UP BIRCH CREEK ROAD. NORTH OF ROAD ON EAST AND WEST FACES OF LIME GULCH.



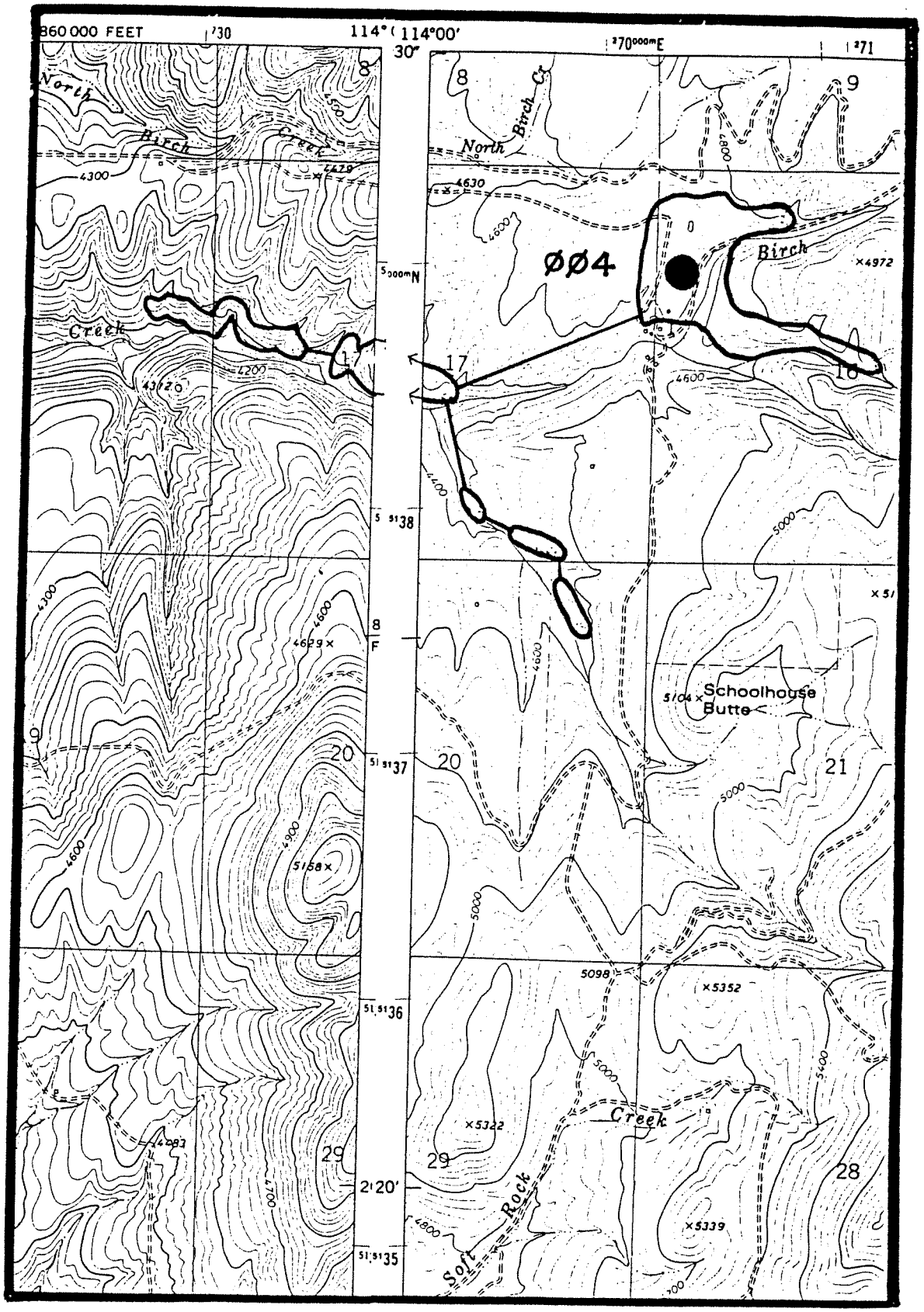
USGS Corvallis (left) and Willow Mountain (right) (7.5') quadrangles.

Charleys Gulch (001)



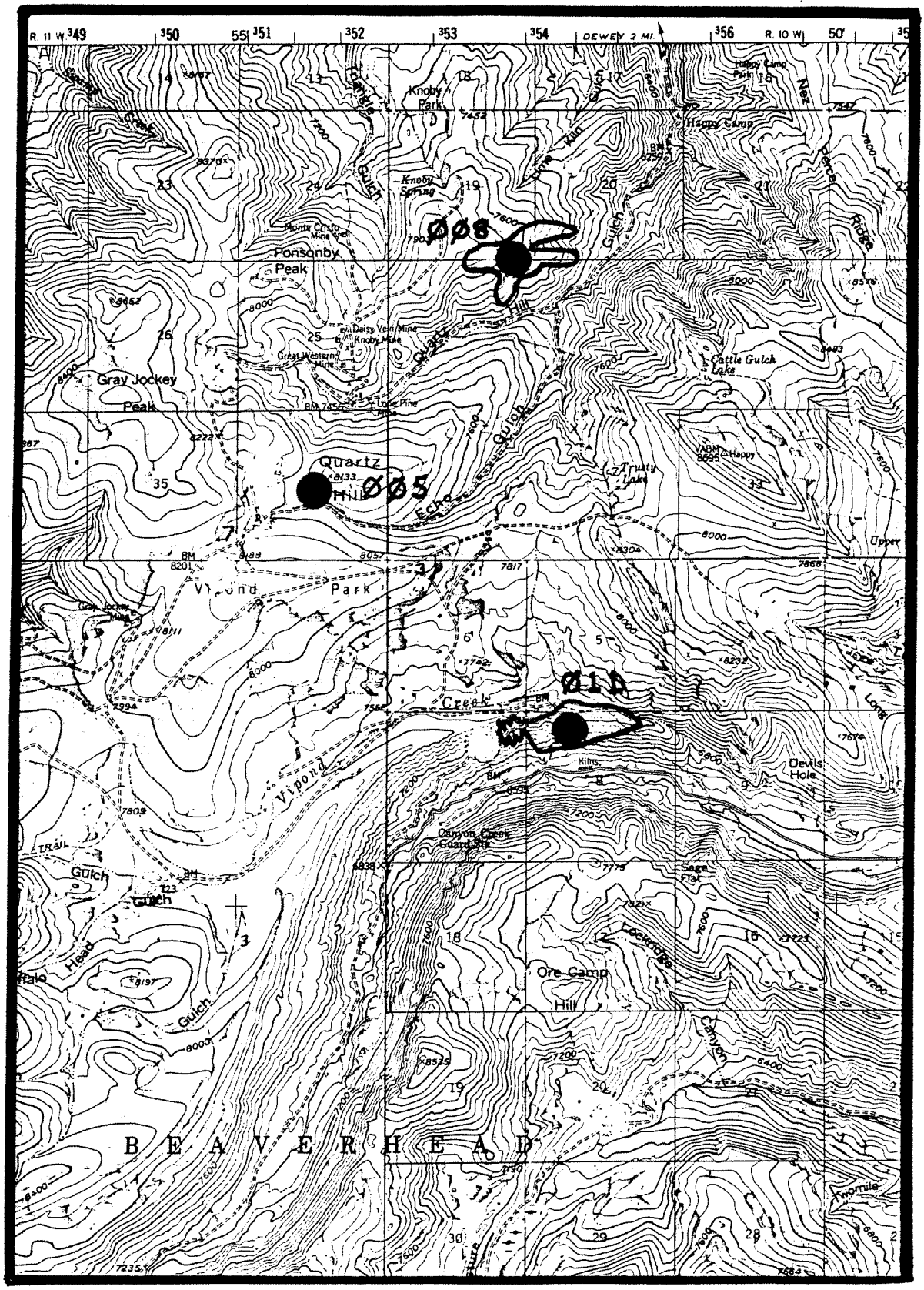
USGS Mountain House (7.5') Quadrangle.

Spring Gulch (002)
Rock Quarry Gulch (003)

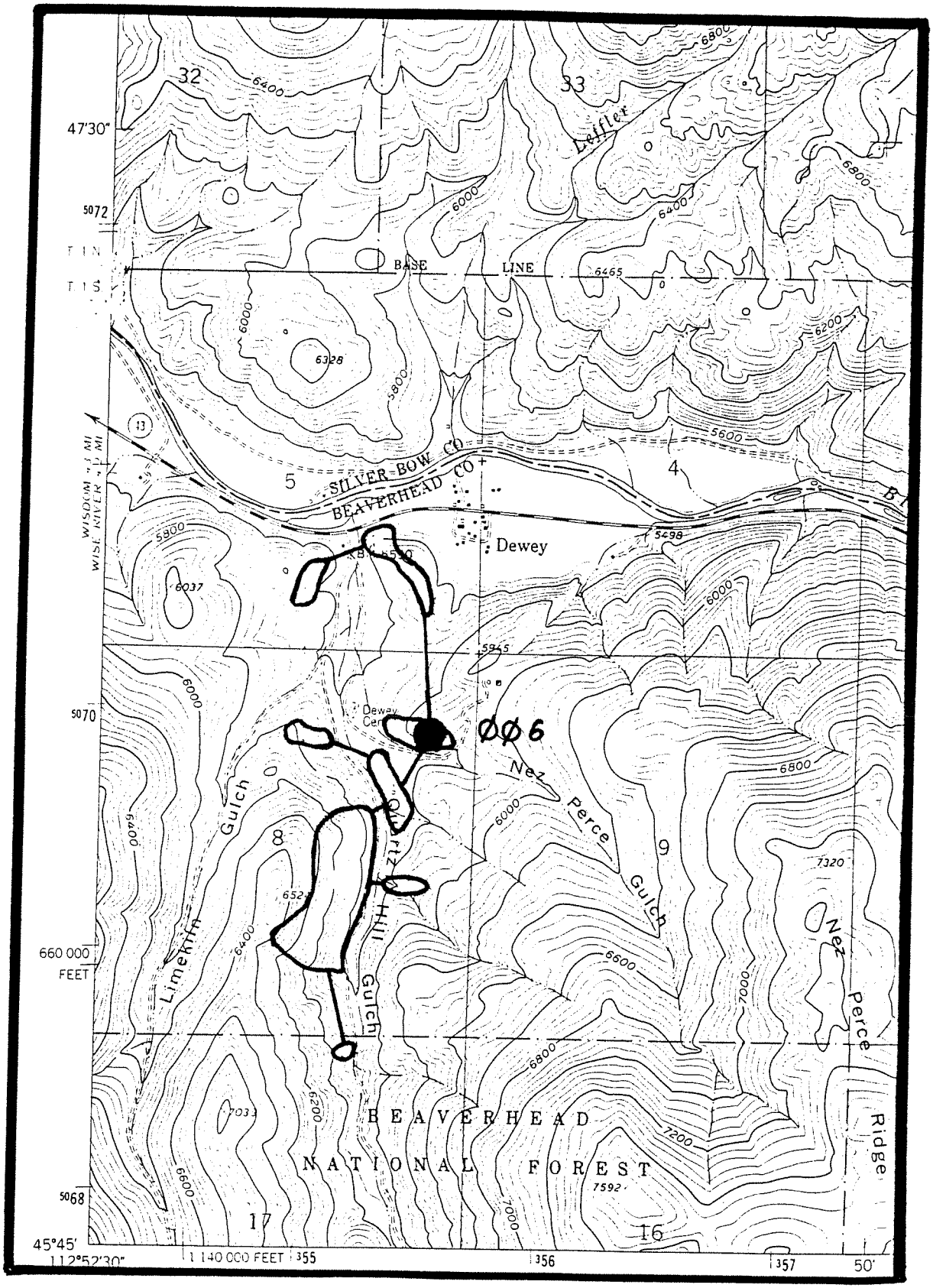


USGS Corvallis (left) and Willow Mountian (right) (7.5') quadrangles.

Birch Creek Bluffs (004)

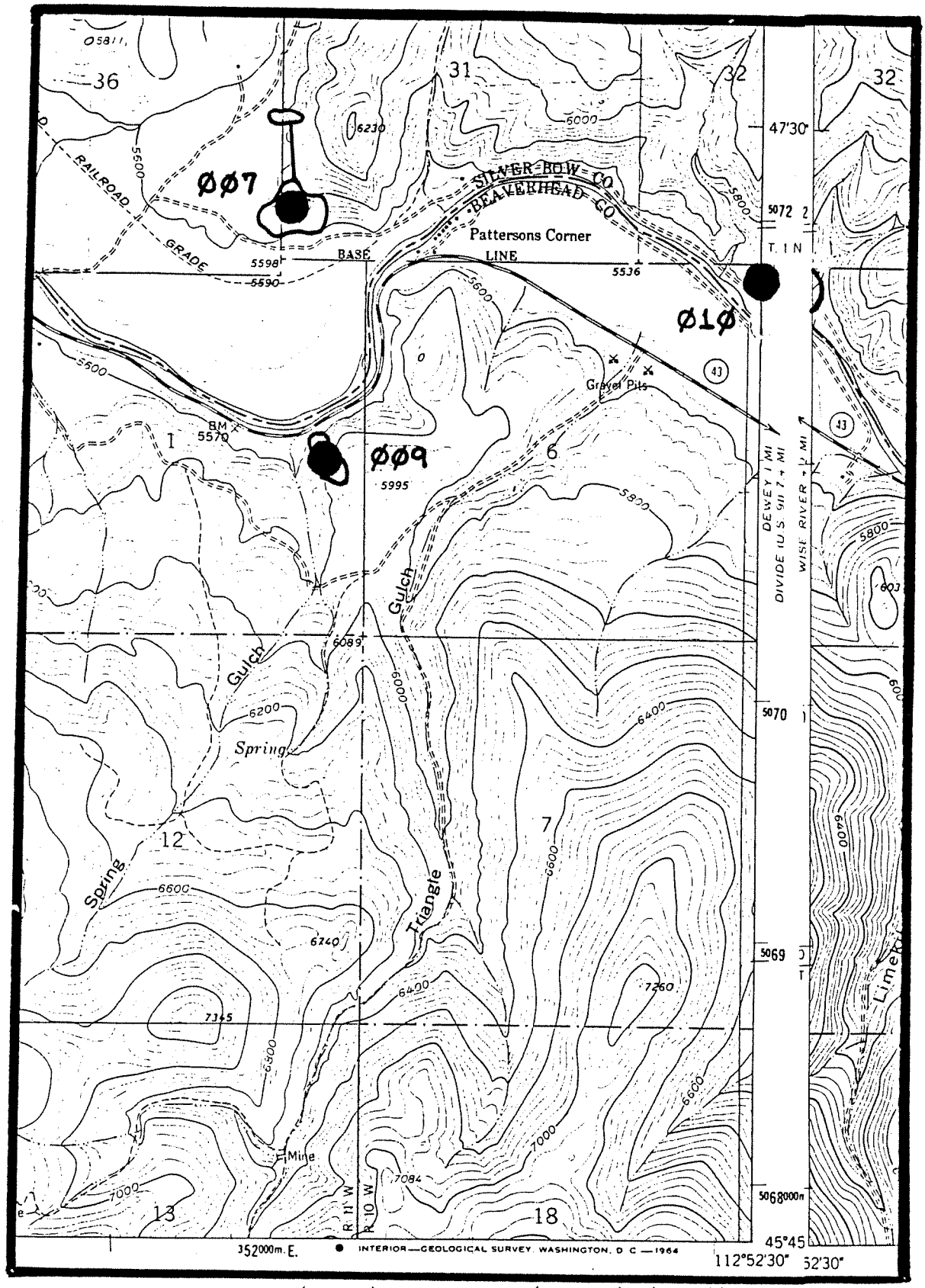


USGS Vipond Park (15') Quadrangle.
Quartz Hill (005)
Upper Quartz Hill Gulch (008)
Vipond Park (011)



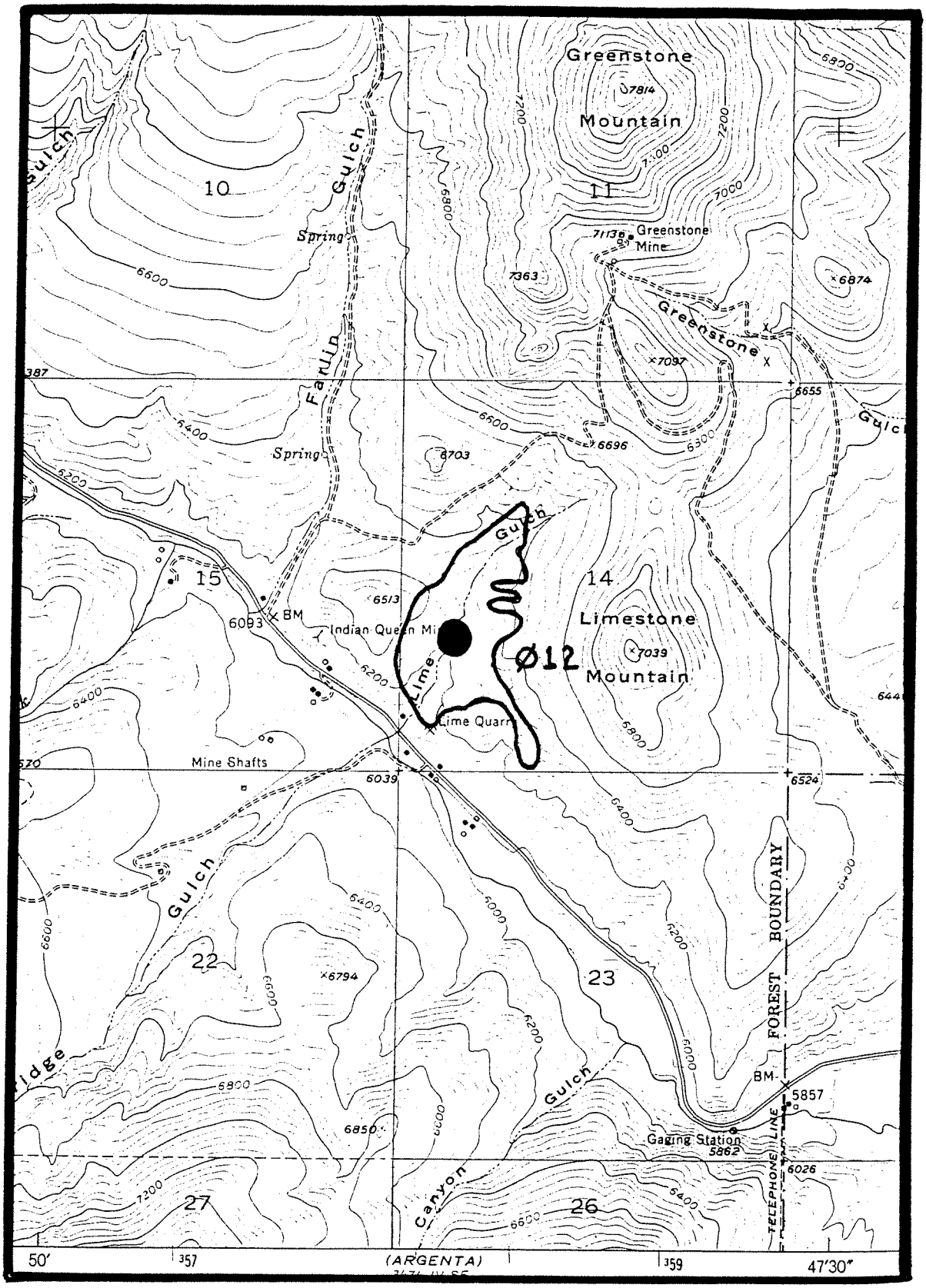
USGS Dewy (7.5') Quadrangle.

Mouth of Quartz Hill Gulch (006)



USGS Wise River (left) and Dewy (right) (7.5') quadrangles.

Mouth of Jerry Creek (007)
Spring Gulch (009)
Wise River (010)



USGS Twin Adams Mountain (7.5') Quadrangle.

Lime Gulch (012)

Shelly, 1988). This report details the possible influence of soil crust on this species.

I.6.C.1. **Vegetation, physiognomy and community structure:** Sites in the Pioneer Mountain drainages are often under a very sparse overstory of Juniperus scopulorum (Rocky Mountain juniper), Pseudotsuga menziesii (Douglas fir) and Pinus ponderosa (ponderosa pine). The dominant shrubs are Cercocarpus ledifolius (curly-leaf mountain mahogany) or Artemisia tridentata (big sagebrush). The associated species at the new site in the foothills of the Sapphire Range, Birch Creek Bluffs (004), are similar to those previously reported from that area.

I.6.C.6. **Dependence on dynamic aspects of biotic associations and ecosystem features:** Arabis fecunda may be influenced by the presence and abundance of Centaurea maculosa (spotted knapweed) at the sites along the eastern edge of the Sapphire Mountains. A report on detailed studies of these effects is included in Appendix B, p. 36 (Lesica and Shelly, 1988).

I.7.A. **GENERAL SUMMARY:** Additional subpopulations and/or numbers of plants were recorded for the three sites in the original report. Charleys Gulch (001) now includes thirteen subpopulations and contains approximately 8,000-10,000 plants. Spring Gulch (002) now includes four subpopulations containing approximately 1,000-1,500 plants. Rock Quarry Gulch (003) still consists of only one population, but additional plants were recorded for this site, bringing the total number to approximately 800-1,000. The new Birch Creek Bluffs (004) population has six subpopulations, with approximately 10,000+ plants, within a radius of 3/4 mile.

Populations and subpopulations in the Pioneer Mountain drainages consist of from 75-10,000 plants. These populations are within a radius of ca. 16 miles of one another. The largest distance separating all known populations is ca. 95 miles (between the Lime Gulch (012) site in the Pioneer Mountains, and the Sapphire Mountain populations).

I.7.B.1. **KNOWN POPULATIONS:** Nine new populations of Arabis fecunda have been discovered since 1985; the total number is now twelve. Eight of these populations occur along the north and east flanks of the Pioneer Mountains and one additional population was found in the foothills of the Sapphire Range. The Element Occurrence records for each of these populations is found in Appendix A, p. 23.

I.7.B.2. a. **Charleys Gulch**

1. **Area:** Thirteen subpopulations covering a total area of ca. 700 acres.
2. **Number and size of plants:** ca. 8,000-10,000+ plants.
3. **Density:** Plant density is often high in localized areas within the site.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of flowering and fruiting plants.
6. **Evidence of expansion/contraction:** None.

b. **Spring Gulch**

1. **Area:** Four subpopulations covering a total area of ca. 160 acres.
2. **Number and size of plants:** ca. 1,000-1,500 individual plants.
3. **Density:** Plants sparsely distributed within the site.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of flowering and fruiting plants.
6. **Evidence of expansion/contraction:** None.

c. **Rock Quarry Gulch**

1. **Area:** One population covering a total area of ca. 5 acres.
2. **Number and size of plants:** ca. 800-1,000+ individual plants.
3. **Density:** Plant density intermediate within the site.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of flowering and fruiting plants.
6. **Evidence of expansion/contraction:** None.

d. **Birch Creek Bluffs**

1. **Area:** Six subpopulations covering a total area of ca. 200 acres.

2. **Number and size of plants:** ca. 10,000+ individual plants, ca. 60% in flower and 20% in fruit in 1986.
3. **Density:** Arabis fecunda frequent in some areas within the site.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of flowering and fruiting plants.
6. **Evidence of expansion/contraction:** None.

e. **Quartz Hill**
1. **Area:** One population with scattered individuals. Total area occupied by Arabis fecunda is ca. 5 acres.
2. **Number and size of plants:** No estimate of population size available.
3. **Density:** Scattered individual plants.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of plants with mature fruits.
6. **Evidence of expansion/contraction:** None.

f. **Mouth of Quartz Hill Gulch**
1. **Area:** Eight subpopulations, over ca. 100 acres.
2. **Number and size of plants:** ca. 7,300 plants, ca. 25% in flower and 15% in fruit in 1988.
3. **Density:** Density of Arabis fecunda high in some areas within the largest subpopulations; otherwise, individual plants were scattered.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of mature fruits.
6. **evidence of expansion/contraction:** None.

g. **Jerry Creek**
1. **Area:** Two subpopulations over ca. 40 acres.
2. **Number and size of plants:** ca. 5,000 plants, ca. 50% with mature fruit in 1988.
3. **Density:** Plant density fairly high in the largest subpopulation, with ca. 20% total cover of Arabis fecunda in some areas; remaining plants scattered.
4. **Presence of dispersed seed:** Unknown.

5. **Evidence of reproduction:** Presence of mature fruits.
6. **Evidence of expansion/contraction:** None.

h. **Upper Quartz Hill Gulch**
1. **Area:** One population on ca. 40 acres.
2. **Number and size of plants:** ca. 75-100 plants, ca. 15% in fruit and 25% in flower in 1988.
3. **Density:** Scattered.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of mature fruit.
6. **Evidence of expansion/contraction:** None.

i. **Spring Gulch II**
1. **Area:** One population scattered over ca. 2 acres.
2. **Number and size of plants:** ca. 100-200 plants, most in fruit in 1988.
3. **Density:** Scattered.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of mature fruit.
6. **Evidence of expansion/contraction:** None.

j. **Big Hole River**
1. **Area:** One population scattered over 1 acre.
2. **Number and size of plants:** ca. 100 plants, 90% in fruit in 1988.
3. **Density:** Scattered.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of mature fruit.
6. **Evidence of expansion/contraction:** None.

k. **Vipond Park**
1. **Area:** Two subpopulations, covering 100 acres.
2. **Number and size of plants:** ca. 10,000 plants, ca. 15% in flower and 60% in fruit in 1988.
3. **Density:** Very dense cover of Arabis fecunda occurs in portions of the site.
4. **Presence of dispersed seed:** Unknown.

5. **Evidence of reproduction:** Presence of mature fruit.
6. **Evidence of expansion/contraction:** None.

1. **Lime Gulch**
   1. **Area:** One large population covering 80 acres.
   2. **Number and size of plants:** ca. 10,000 plants, ca. 90% in fruit in 1988.
   3. **Density:** Greater than 20% cover of Arabis fecunda within parts of the site.
   4. **Presence of dispersed seed:** Unknown.
   5. **Evidence of reproduction:** Presence of mature fruit.
   6. **Evidence of expansion/contraction:** None.

I.7.C.

1. **Patterns:** The Pioneer Mountain sites were first visited in early July of 1988. At that time, five of the eight populations were still partially in flower. These high elevation sites extend the flowering dates for the known populations into early July, and fruiting is likely to occur through mid- or late July.

I.7.D.4. **Seed biology**

a. **Amount and variation of seed production:** There appears to be some variation with respect to yearly seed production by Arabis fecunda at some sites. See Appendix B, p. 36 (Lesica and Shelly, 1988) for detailed information.

I.7.D.6. **Survival and mortality:** Mortality and recruitment appear to be nearly equal in some populations of Arabis fecunda; however, disturbance by livestock may have an influence on these processes at some sites. See Appendix B, p. 36 (Lesica and Shelly, 1988) for detailed information.

I.8.C.2. b. **Interspecific:** The exotic weed Centaurea maculosa (spotted knapweed) may have an influence on populations of Arabis fecunda. A report from an ongoing study of the interactions between these two species, from sites

near the Sapphire Range, is contained in Appendix B, p. 36.

I.9.A. **General nature of ownership:** The sites in the Pioneer Mountain drainages are on U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, and State of Montana lands.

I.9.B. **Specific landowners:**

1. USDA Forest Service
   Beaverhead National Forest
   610 N. Montana Street
   Dillon, MT 59725

2. USDI Bureau of Land Management
   Headwaters Resource Area
   P.O. Box 3388
   Butte, MT 59702

3. Montana Department of State Lands
   1625 11th Avenue
   Helena, MT 59620

4. Several sites are partially or wholly privately owned. These include:

   Charleys Gulch (001)
   Spring Gulch (002)
   Rock Quarry Gulch (003)
   Birch Creek Bluffs (004)
   Wise River (010)

I.9.C. **Management responsibility:** Same as ownership.

I.9.D. **Easements, conservation restrictions, etc.:** A portion of the Charleys Gulch Site is registered with The Nature Conservancy by the owner (George Frost). Although such registry is not legally binding, the owner agrees to preserve the populations present, and to inform The Nature Conservancy of any proposed land management changes.

I.11.A.1. **Present or threatened destruction, modification, or curtailment of habitat or range:** The Birch Creek Bluffs population (004) may be threatened by weed invasion by Centaurea maculosa (spotted knapweed). The Mouth of Quartz Hill Gulch subpopulation (006) closest to the road is threatened by gravel removal from the base of the hill.

The Jerry Creek population (007) is threatened by grazing and trampling by cattle. The lower portion of the hill where this population occurs was heavily trailed and disturbed.

II.12. **General assessment of vigor, trends and status:** Arabis fecunda is now know from twelve populations, within a radius of ca. 47 miles. Centaurea maculosa (spotted knapweed) is currently not a threat to populations along the flanks of the Pioneer Range, but may pose a threat to the Birch Creek Bluffs site in the foothills of the Sapphire Range. Reproductive output and vigor of Arabis fecunda appears to be normal at the newly discovered sites.

II.13.A. **Recommendation to U.S. Fish and Wildlife Service:** Peter Lesica submitted a petition to list Arabis fecunda just prior to the discovery of the new populations along the flanks of the Pioneer Mountains. Subsequent to these discoveries the petition was retracted. It is recommended that Arabis fecunda be retained in Category 2 until further distribution and ecological studies can be conducted.

II.13.B. **U.S. Forest Service:** Arabis fecunda is now known to occur on lands administered by the U.S. Forest Service. Thus, it should be placed on the list of sensitive species in Region 1 for Montana.

II.15.A. 1. **Recommendations regarding present or anticipated activities:** The effects of mining or increased grazing in areas supporting populations of Arabis fecunda should be assessed before any of these activities are implemented.

2. **Areas recommended for protection:** The Vipond Park site (011) is a large, representative population of Arabis fecunda on Forest Service lands, and should be proposed for special designation. The Quartz Hill site (005), although not yet thoroughly surveyed, is recommended for protection because of its close proximity to two other rare plant populations (Penstemon lemhiensis (Lemhi penstemon) and Claytonia lanceolata var. flava (yellow springbeauty)). Both of these

are USFWS Category 2 taxa and USFS Region 1 sensitive species.

II.16 **Interested parties:**

Lisa Ann Schassberger
Montana Natural Heritage Program
State Library Building
1515 E. 6th Ave
Helena, MT 59620

III.17.C. **1. Surveys:**

Steve Shelly, Montana Natural Heritage Program

8 May 1986 (001; Charleys Gulch)
19-20 May 1987
19-20 May 1988
1-3 June 1988

Peter Lesica, The Nature Conservancy

8 May 1986 (001; Charleys Gulch)
27-30 May 1986
19-20 May 1987
19-20 May 1988

Lisa A. Schassberger, Montana Natural Heritage Program

1-3 June 1988
6-7 June 1988
13-15 June 1988

III.17.D. **Knowledgeable individuals:**

Lisa Schassberger
Montana Natural Heritage Program
State Library Building
1515 E. 6th Ave.
Helena, MT 59620

III.18. **Summary of materials on file:** All detailed field forms, maps and color slides are on file at the office of the Montana Natural Heritage Program. Herbarium vouchers for Montana populations will be deposited at the University of Montana Herbarium (MONTU).

Literature Cited

Lesica, P. and J.S. Shelly. 1988. The Ecology of Arabis fecunda: Long-term Monitoring, Knapweed Removal, and Soil Crust Ecology Studies, 1988 Progress Report; unpublished. 16 pp.

Richards, R.W. and J.T. Pardee. 1925. The Melrose Phosphate Field, Montana. U.S.G.S. Bull. 780: 1-32.

U.S. Department of Commerce. 1982. Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80. National Oceanic and Atmospheric Administration, Climatography of the United States No. 81. 23 pp.

APPENDIX A

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.001
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 1 TENTEN: 10,10 IDENT: Y EORANK: B
SURVEYSITE: CHARLEYS GULCH
EORANKCOMM: LARGE POPULATION, BUT AREA IMPACTED BY WEEDS AND GRAZING.
SURVEYDATE: 1988-06-01 LASTOBS: 1988-06-01 FIRSTOBS: 1975 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTRAVA
QUADCODE: 4611431 4611338
QUADNAME: CORVALLIS, WILLOW MOUNTAIN PRECISION: SC
LAT: 461531 LONG: 1140000 S: 461509 N: 461603 E: 1135948 W: 1140128
TOWNRANGE: 006N019W SECTION: 20 MERIDIAN: PR TRSCOMM: W2,W2NE4;19S 2;29NW4+
PHYSPROV: NR WATERSHED: 17010205 RIVERREACH:
DIRECTIONS: ALSO 30,N2. CHARLEYS GULCH, WEST SLOPE OF SAPPHIRE RANGE, ALONG CHARLEYS GULCH ROAD CA. 1.1-2.1 MILES FROM JUNCTION WITH PAVED COUNTY ROAD; ALSO NORTH AND SOUTH OF GULCH.
GENDESC: ON STEEP, W- AND SW-FACING SLOPES, ON LIGHT-COLORED LIMESTONE OUTCROPS, IN SAGEBRUSH GRASSLAND WITH CHRYSOPSIS VILLOSA, GILIA SPICATA, PHYSARIA GEYERI, ALYSSUM ALYSSOIDES.
ELEV: 5000 SIZE: 700
EODATA: CA. 8000-10000+ PLANTS, IN 13 SUBPOPULATIONS; EVIDENCE OF DISTURBANCE BY CATTLE; WEED INVASION BY SPOTTED KNAPWEED (CENTAUREA MACULOSA) A SERIOUS THREAT.

COMMENTS: CENTRUM IS THE TYPE LOCALITY; MONITORING TRANSECTS ESTABLISHED BY LESICA AND SHELLY, 87-05-19.
MACODE1: PRIVATEOWNMTUS CONTAINED1: N MACODE2: SSLGNXXXX1MTUS CONTAINED2: N
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: SEE U85LES01MTUS,ELEMENT FILE.
OWNERCOMM:
PROTCOMM: BITTERROOT N.F. PARCEL HAS BEEN TRADED.
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SHELLY, J.S. 1988. FIELD SURVEYS IN RAVALLI COUNTY OF 19-20 MAY, 1-3 JUNE.
SOURCECODE: F88SHE02MTUS PNDSHE01MTUS A84ROL01MTUS PNDSCH02MTUS U85LES01MTUS S76CORUMMTUS S85LESUMMTUS U85LES02MTUS PNDLES01MTUS
DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 86-01-21 JSS CDREV: Y MAPPER: 86-01-21 JSS QC: Y
UPDATE: 88-09-02 JSS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.002
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 1 TENTEN: 9,1 IDENT: Y EORANK: BC
SURVEYSITE: SPRING GULCH
EORANKCOMM: MODERATE-SIZED POPULATION, SOME IMPACTS FROM GRAZING.
SURVEYDATE: 1988-06-01 LASTOBS: 1988-06-01 FIRSTOBS: 1985 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTRAVA
QUADCODE: 4611421
QUADNAME: MOUNTAIN HOUSE PRECISION: SC
LAT: 461452 LONG: 1140109 S: 461421 N: 461454 E: 1140044 W: 1140126
TOWNRANGE: 006N019W SECTION: 30 MERIDIAN: PR TRSCOMM: S2,31NE4NW4

PHYSPROV: NR WATERSHED: 17010205 RIVERREACH:
DIRECTIONS: SPRING GULCH, WEST SLOPE OF SAPPHIRE RANGE; AT JCT. OF HWYS. 269 & 380, 2.5 MI. E. TO WHERE 380 TURNS N.; E. 1.5 MI. TO CHARLEYS GULCH RD., 2 MI. TO CATTLEGUARD; SITES 1 MI. SW.
GENDESC: ON LIGHT-COLORED GRANITIC AND CALCAREOUS ROCK OUTCROPS, ON STEEP, S-FACING SLOPES; SAGEBRUSH GRASSLAND WITH PINUS PONDEROSA,HAPLOPAPPUS ARMERIOIDES,GILIA SPICATA, CRYPTANTHA.
ELEV: 4740 SIZE: 160
EODATA: CA. 1000-1500+ PLANTS, 4 SUBPOPULATIONS; EVIDENCE OF DISTURBANCE BY CATTLE; SITES THREATENED BY WEEDY SPECIES (ESP. CENTAUREA MACULOSA); REMOTE AREA.

COMMENTS: VOUCHER-LESICA, P. (3339), 1985, MONTU.

MACODE1: PRIVATEOWNMTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BITTERROOT STOCK FARM, INC.
OWNERCOMM: C. BREESE, P.O. BOX 271, HAMILTON, MT 59840.
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM: -
BESTSOURCE: SHELLY, J.S. 1988. FIELD SURVEYS IN RAVALLI COUNTY OF 19-20 MAY, 1-3 JUNE.
SOURCECODE: F88SHE02MTUS S85LESUMMTUS A84ROL01MTUS U85LES01MTUS PNDCOR01MTUS U85LES02MTUS PNDLES01MTUS PNDSHE01MTUS PNDTAY01MTUS
DATASENS: N BOUNDARIES: Y PHOTOS: OWNERINFO:
TRANSCRIBR: 86-01-21 JSS CDREV: Y MAPPER: 86-01-21 JSS QC: Y
UPDATE: 88-10-13 JSS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.003
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 2 TENTEN: 8,2 IDENT: Y EORANK: B
SURVEYSITE: ROCK QUARRY GULCH
EORANKCOMM: FAIRLY LARGE POPULATION, HABITAT NOT HEAVILY DISTURBED.
SURVEYDATE: 1988-06-01 LASTOBS: 1988-06-01 FIRSTOBS: 1985 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTRAVA
QUADCODE: 4611421
QUADNAME: MOUNTAIN HOUSE PRECISION: SC
LAT: 461358 LONG: 1140137 S: 461356 N: 461401 E: 1140131 W: 1140142
TOWNRANGE: 006N019W SECTION: 31 MERIDIAN: PR TRSCOMM: NW4SW4

PHYSPROV: NR WATERSHED: 17010205 RIVERREACH:
DIRECTIONS: ROCK QUARRY GULCH; FROM JCT. OF HWYS. 269 & 380, GO 2.5 MI. E. TO CORNER WHERE 380 TURNS N.; GO E. 1.5 MI. TO CHARLEYS GULCH RD., & 2 MI. TO CATTLEGUARD; SITE IS 2 MILES SW.
GENDESC: ON LIGHT-COLORED ROCK OUTCROPS ON OPEN, S-FACING SLOPES; IN SAGEBRUSH GRASSLAND NEAR LOWER TREELINE, W/ SCATTERED PINUS PONDEROSA, AGROPYRON SPICATUM, HAPLOPAPPUS ARMERIOIDES.
ELEV: 4850 SIZE: 5
EODATA: CA. 800-1000+ PLANTS, ONE POPULATION; EVIDENCE OF LIGHT DISTURBANCE BY CATTLE; POPULATION THREATENED BY KNAPWEED (CENTAUREA SP.) INVASION, BUT SITE NOT AS WEEDY AS OTHERS IN AREA.
COMMENTS: VOUCHER-LESICA, P. (3340), 1985, MONTU; RECENTLY DESCRIBED STATE ENDEMIC (1984).
MACODE1: PRIVATEOWNMTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BITTERROOT STOCK FARM, INC.
OWNERCOMM: C. BREESE, P.O. BOX 271, HAMILTON, MT 59840.
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SHELLY, J.S. 1988. FIELD SURVEYS IN RAVALLI COUNTY OF 19-20 MAY, 1-3 JUNE.
SOURCECODE: F88SHE02MTUS PNDSHE01MTUS A84ROL01MTUS U85LES01MTUS PNDCOR01MTUS U85LES02MTUS PNDLES01MTUS S85LESUMMTUS
DATASENS: N BOUNDARIES: Y PHOTOS: N OWNERINFO:
TRANSCRIBR: 86-01-21 JSS CDREV: Y MAPPER: 86-01-21 JSS QC: Y
UPDATE: 88-09-12 JSS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.004
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 2 TENTEN: 1,1 IDENT: Y EORANK: AB
SURVEYSITE: BIRCH CREEK BLUFFS
EORANKCOMM: VERY LARGE POPULATION, SOME AREAS IN GOOD CONDITION.
SURVEYDATE: 1988-06-01 LASTOBS: 1988-06-01 FIRSTOBS: 1986 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTRAVA
QUADCODE: 4611338 4611431
QUADNAME: WILLOW MOUNTAIN,CORVALLIS PRECISION: SC
LAT: 462201 LONG: 1135911 S: 462112 N: 462212 E: 1135831 W: 1140045
TOWNRANGE: 007N019W SECTION: 16 MERIDIAN: PR TRSCOMM: NW4,17,18NE4
,20NE4
PHYSPROV: NR WATERSHED: 17010205 RIVERREACH:
DIRECTIONS: WESTERN LOWER SLOPES OF SAPPHIRE MOUNTAINS, ALONG BIRCH CREEK AND TRIBUTARY NW. OF SCHOOLHOUSE BUTTE, CA. 7 AIR MILES ENE. OF CORVALLIS.
GENDESC: WHITE, HIGHLY CALCAREOUS, ERODING SLOPES OF METAMORPHOSED CALC-SILICATES; WITH PINUS PONDEROSA, JUNIPERUS SCOPULORUM, HAPLOPAPPUS ARMERIOIDES, LESQUERELLA ALPINA, POA SECUNDA.
ELEV: 4700 SIZE: 200
EODATA: 10,000+ INDIVIDUALS, CA. SIX SUBPOPULATIONS; SLOPES ARE TERRACED FROM LIVESTOCK GRAZING, AND WEEDS (CENTAUREA MACULOSA, BROMUS TECTORUM, ALYSSUM) ARE ABUNDANT; ALSO WITH AGROPYRON SPICATUM, OXYTROPIS BESSEYI, SENECIO CANUS.
COMMENTS: VOUCHERS-LESICA, P. (3744), 1986, MONTU; SHELLY, J.S.(1414), 1988, MONTU; MONITORING TRANSECTS ESTABLISHED 87-5-20.
MACODE1: SSLGNXXXX1MTUS CONTAINED1: N MACODE2: PRIVATEOWNMTUS CONTAINED2: N
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME: BIRCH CREEK BLUFFS
OWNER: DOUBLE FORK LAND CO.
OWNERCOMM: 1953 EASTSIDE HWY, CORVALLIS, MT 59828.
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SHELLY, J.S. 1988. FIELD SURVEYS IN RAVALLI COUNTY OF 19-20 MAY, 1-3 JUNE.
SOURCECODE: F88SHE02MTUS S86LESUMMTUS A84ROL01MTUS PNDSHE01MTUS PNDLES01MTUS S88SHEUMMTUS
DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 86-06-06 JSS CDREV: Y MAPPER: 86-06-06 JSS QC: Y
UPDATE: 88-10-13 JSS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.005
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 15 TENTEN: 4,2 IDENT: Y EORANK: BC
SURVEYSITE: QUARTZ HILL
EORANKCOMM: SMALL POPULATION, BUT AREA NOT THOROUGHLY SURVEYED.
SURVEYDATE: 1986-07-08 LASTOBS: 1986-07-08 FIRSTOBS: 1986 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511268
QUADNAME: VIPOND PARK (15) PRECISION: SC
LAT: 454224 LONG: 1125421 S: 0 N: 0 E: 0 W: 0
TOWNRANGE: 001S011W SECTION: 36 MERIDIAN: PR TRSCOMM: CENTER

PHYSPROV: NR WATERSHED: 10020004 RIVERREACH: 10020004157 00.00
DIRECTIONS: PIONEER MOUNTAINS, ECHO GULCH, SOUTHWEST BASE OF QUARTZ HILL

GENDESC: ON OPEN GRAVELLY LIMESTONE SLOPE, IN PINUS CONTORTA ZONE.

ELEV: 8000 SIZE: 5
EODATA: SCATTERED.

COMMENTS:

MACODE1: FFSNFBEAV2MTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BEAVERHEAD NATIONAL FOREST
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SHELLY, J.S. (1193). 1986. MONTU.

SOURCECODE: PNDSHE01MTUS S86SHEUMMTUS

DATASENS: N BOUNDARIES: N PHOTOS: N OWNERINFO:
TRANSCRIBR: 88-08-25 JSS CDREV: Y MAPPER: 88-08-25 JSS QC: Y
UPDATE: 88-09-02 MEZ

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.006
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 2 TENTEN: 2,9 IDENT: Y EORANK: AB
SURVEYSITE: MOUTH OF QHARTZ HILL GULCH
EORANKCOMM: EXCELLENT SITE, BUT CLOSE TO ROAD.
SURVEYDATE: 1988-06-06 LASTOBS: 1988-06-13 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511277
QUADNAME: DEWEY PRECISION: SC
LAT: 454608 LONG: 1125126 S: 454524 N: 454637 E: 1125120 W: 1125157
TOWNRANGE: 001S010W SECTION: 08 MERIDIAN: PR TRSCOMM: E2;S5,SE4;S17,NE4
PHYSPROV: NR WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: BEAVERHEAD NATIONAL FOREST. TRAVEL 0.25 MILE WEST OF DEWEY ON HIGHWAY 43, THEN SOUTH ON QUARTZ HILL GULCH, EAST AND WEST OF THE ROAD FOR 1.5 MILES.
GENDESC: CALC-SILICATE ROCKY OUTCROPS AND HILLSIDES; BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS AND DRABA NIVALIS.
ELEV: 5780 SIZE: 100
EODATA: CA. 7,300 PLANTS IN 8 SUBPOPULATIONS; FRUITING.

COMMENTS: VOUCHER, SCHASSBERGER (205). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING SUBPOPULATIONS.
MACODE1: FFSNFBEAV2MTUS CONTAINED1: Y MACODE2: CONTAINED2:
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BEAVERHEAD NATIONAL FOREST
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY, SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE, 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-12-20 LAS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.007
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 4 TENTEN: 8,7 IDENT: Y EORANK: B
SURVEYSITE: JERRY CREEK
EORANKCOMM: LARGE POPULATION BUT HEAVY GRAZING NEARBY.
SURVEYDATE: 1988-06-07 LASTOBS: 1988-06-07 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTSILV
QUADCODE: 4511278
QUADNAME: WISE RIVER PRECISION: SC
LAT: 454718 LONG: 1125402 S: 454715 N: 454731 E: 1125354 W: 1125408
TOWNRANGE: 001N010W SECTION: 31 MERIDIAN: PR TRSCOMM: SW4,R11W:S36
,SE4
PHYSPROV: MB WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: CA. 1.5 MILES EAST OF WISE RIVER ON HIGHWAY 43, NE ON JERRY CREEK ROAD 0.3 MILE; HILLSIDES AND OUTCROPS EAST OF ROAD.

GENDESC: CALC-SILICATE OUTCROPS & HILLSIDES IN OPEN SOILS, BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CER- C OCARPUS LEDIFOLIUS AND ERIGERON COMPOSITUS.
ELEV: 5700 SIZE: 30
EODATA: CA. 5,050 PLANTS IN 2 SUBPOPULATIONS, FLOWERING AND FRUITING; THREATENED BY OVER-GRAZING.

COMMENTS: VOUCHER - SCHASSBERGER (207). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING SUBPOPULATIONS.
MACODE1: FBLDOBUTT4MTUS CONTAINED1: N MACODE2: SSLGNXXXX1MTUS CONTAINED2:
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BLM/STATE OF MONTANA
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY IN SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-04 LAS QC: Y
UPDATE: 88-12-20 LAS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.008
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 16 TENTEN: 5,1 IDENT: Y EORANK: AB
SURVEYSITE: UPPER QUARTZ HILL GULCH
EORANKCOMM: PAST MINING DISTURBANCES; SMALL POPULATION.
SURVEYDATE: 1988-06-07 LASTOBS: 1988-06-07 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511257
QUADNAME: VIPOND PARK PRECISION: SC
LAT: 454345 LONG: 1125242 S: 45 N: 454358 E: 1125210 W: 1125307
TOWNRANGE: 001S010W SECTION: 19 MERIDIAN: PR TRSCOMM: SE4,20SW4;29 SW4;+
PHYSPROV: MB WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: 30SE4. CA. 3.75 MILES SOUTH OF DEWEY ON QUARTZ HILL GULCH ROAD, CA. 0.2 MILE SW OF ROAD ON ROCKY OUTCROPS AND SOILS.

GENDESC: CALC-SILICATE ROCKY OUTCROPS AND HILLSIDES; BENEATH PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS AND DRABA NIVALIS.
ELEV: 7500 SIZE: 40
EODATA: CA. 75-100 PLANTS, FLOWERING AND FRUITING. SCATTERED PLANTS, USUALLY ON EXPOSED OUTCROPS.

COMMENTS: VOUCHER - SCHASSBERGER (205) 1988. MONTU. SEE GMF FOR BASE MAP SHOWING POPULATION.
MACODE1: FFSNFBEAV2MTUS CONTAINED1: Y MACODE2: CONTAINED2:
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BEAVERHEAD NATIONAL FOREST
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY OF SOUTHWESTERN MONTANA, 1-2, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-11-03 MEZ

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.009
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 5 TENTEN: 8,8 IDENT: Y EORANK: AB
SURVEYSITE: SPRING GULCH
EORANKCOMM: SMALLER POPULATION, NATURALLY PROTECTED.
SURVEYDATE: 1988-06-07 LASTOBS: 1988-06-07 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511278
QUADNAME: WISE RIVER PRECISION: SC
LAT: 454643 LONG: 1125354 S: 454640 N: 454648 E: 1125349 W: 1125357
TOWNRANGE: 001S011W SECTION: 01 MERIDIAN: PR TRSCOMM: SE4

PHYSPROV: NR WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: CA. 2.2 MILES EAST OF WISE RIVER ON HIGHWAY 43. AT BEND, 0.20 MILE SOUTH OF ROAD ATOP STEEP CLIFFS.

GENDESC: ON CALC-SILICATE ROCKY OUTCROPS BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS.

ELEV: 5600 SIZE: 10
EODATA: CA. 100-200 PLANTS, FRUITING; SPARSELY DISTRIBUTED.

COMMENTS: VOUCHER - SCHASSBERGER (207). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING POPULATION.
MACODE1: FBLDOBUTT2MTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BLM
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY, SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-12-20 LAS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.010
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 6 TENTEN: 10,7 IDENT: Y EORANK: AB
SURVEYSITE: WISE RIVER
EORANKCOMM: AREA IS GRAZED.
SURVEYDATE: 1988-06-07 LASTOBS: 1988-06-07 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTSILV
QUADCODE: 4511278 4511277
QUADNAME: WISE RIVER, DEWEY PRECISION: SC
LAT: 454709 LONG: 1125230 S: 454705 N: 454711 E: 1125228 W: 1125233
TOWNRANGE: 001S01OW SECTION: 06 MERIDIAN: PR TRSCOMM: NE4NE4,5NW4N W4
PHYSPROV: NR WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: 1.0 MILE WEST OF DEWEY ON HIGHWAY 43, 0.33 MILE NORTH OF ROAD ON THE NORTH SIDE OF WISE RIVER.

GENDESC: ON CALC-SILICATE ROCKY OUTCROPS AND SOILS, BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS.
ELEV: 5600 SIZE: 1
EODATA: CA. 100+ PLANTS, FRUITING.

COMMENTS: VOUCHER - SCHASSBERGER (207). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING POPULATION.
MACODE1: FBLDOBUTT4MTUS CONTAINED1: N MACODE2: PRIVATEOWNMTUS CONTAINED2:
MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BLM / PRIVATE
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY OF SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-12-20 LAS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.011
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 17 TENTEN: 5,3 IDENT: Y EORANK: AA
SURVEYSITE: VIPOND PARK
EORANKCOMM: EXCELLENT SITE, LARGE POPULATION.
SURVEYDATE: 1988-06-13 LASTOBS: 1988-06-13 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511257
QUADNAME: VIPOND PARK PRECISION: SC
LAT: 454059 LONG: 1125213 S: 454050 N: 454108 E: 1125135 W: 1125248
TOWNRANGE: 002S010W SECTION: 08 MERIDIAN: PR TRSCOMM: N2,7NE4,5S2

PHYSPROV: NR WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: FROM MELROSE, CA. 12.5 MILES WEST, UP CANYON CREEK ROAD, AT CORNER OVERLOOKING KILNS.

GENDESC: ON CALC-SILICATE ROCKY SOILS AND HILLSIDES, BENEATH PINUS FLEXILIS/PSEUDOTSUGA MENZIESII, WITH ARTEMISIA TRIDENTATA, A. FRIGIDA AND ERIGERON COMPOSITUS.
ELEV: 7200 SIZE: 100
EODATA: CA. 10,000 FLOWERING PLANTS IN 2 SUBPOPULATIONS; FLOWERING AND FRUITING OVER A LARGE AREA.

COMMENTS: VOUCHER - SCHASSBERGER (211). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING SUBPOPULATIONS.
MACODE1: FFSNFBEAV2MTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BEAVERHEAD NATIONAL FOREST
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988 FIELD SURVEY, SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-12-20 LAS

ELEMENT OCCURRENCE RECORD

EOCODE: PDBRA06290.012
NAME: ARABIS FECUNDA
COMNAME: SAPPHIRE ROCKCRESS
MARGNUM: 2 TENTEN: 5,9 IDENT: Y EORANK: AB
SURVEYSITE: LIME GULCH
EORANKCOMM: GOOD SITE BUT CLOSE TO ROAD.
SURVEYDATE: 1988-06-15 LASTOBS: 1988-06-15 FIRSTOBS: 1988 GRANK: G2
SRANK: S2 STATE: MT COUNTYNAME: MTBEAV
QUADCODE: 4511247
QUADNAME: TWIN ADAMS MOUNTAIN PRECISION: SC
LAT: 452352 LONG: 1124844 S: 452343 N: 452409 E: 1124827 W: 1124855
TOWNRANGE: 005S010W SECTION: 14 MERIDIAN: PR TRSCOMM: W2,15SE4

PHYSPROV: NR WATERSHED: 10020004 RIVERREACH:
DIRECTIONS: 5 MILES WEST OF INTERSTATE-15, UP BIRCH CREEK ROAD. NORTH OF ROAD ON EAST AND WEST FACES OF LIME GULCH.

GENDESC: CALC-SILICATE ROCK OUTCROPS AND HILLSIDES, BENEATH JUNIPERUS SCOPULORUM, WITH CERCOCARPUS LEDIFOLIUS, SENECIO CANUS AND ERIGERON COMPOSITUS.
ELEV: 6200 SIZE: 80
EODATA: CA. 10,000+ PLANTS, FRUITING. OLD MINING ACTIVITY IN AREA.

COMMENTS: VOUCHER - SCHASSBERGER (217). 1988. MONTU. SEE GMF FOR BASE MAP SHOWING POPULATION.
MACODE1: FFSNFBEAV2MTUS CONTAINED1: Y MACODE2: CONTAINED2:

MACODE3: CONTAINED3: ADLMAS: MORELAN: MOREPROT:
MOREMGMT: Z SITECODE:
SITENAME:
OWNER: BEAVERHEAD NATIONAL FOREST
OWNERCOMM:
PROTCOMM:
MGMTCOMM:
MONITOR: MONITORNUM:
BESTSOURCE: SCHASSBERGER, L.A. 1988. FIELD SURVEY, SOUTHWEST MONTANA, 1-3, 6-7 AND 13-15 JUNE 1988.
SOURCECODE: F88SCH02MTUS PNDSCH02MTUS S88SCHUMMTUS

DATASENS: N BOUNDARIES: Y PHOTOS: Y OWNERINFO:
TRANSCRIBR: 88-08-03 LAS CDREV: Y MAPPER: 88-10-05 LAS QC: Y
UPDATE: 88-12-20 LAS

APPENDIX B

THE ECOLOGY OF *Arabis fecunda*: LONG-TERM MONITORING, KNAPWEED REMOVAL, AND SOIL CRUST ECOLOGY STUDIES.

1988 PROGRESS REPORT

Peter Lesica
The Nature Conservancy
Montana/Wyoming Field Office
P.O. Box 258
Helena, MT 59624

and

J. Stephen Shelly
Montana Natural Heritage Program
State Library Building
1515 E. 6th Avenue
Helena, MT 59620

December 1988

INTRODUCTION

In order to adequately protect populations of an organism, it is necessary to understand its life history and population dynamics (Massey and Whitson 1980; Sutter 1986; Palmer 1987). In addition, many rare species are threatened by interactions with non-native species that have been introduced into their habitat (Drake 1988). It is important to understand the nature of these interactions in order to protect populations of rare species from extinction.

Arabis fecunda Rollins (Sapphire rockcress) is a rosette-forming perennial in the mustard family (Brassicaceae). This recently described species (Rollins 1984) is endemic to highly calcareous, azonal soils in the foothills of the Sapphire and Pioneer mountains in Ravalli, Beaverhead and Silver Bow counties, Montana (Lesica 1985; Schassberger 1988). Arabis fecunda occurs on eroding slopes with low vascular plant density but a relatively high cover of cryptogamic soil crust. Populations of A. fecunda are thought to be threatened by livestock grazing and encroachment by Centaurea maculosa Lam. (spotted knapweed), an aggressive exotic weed (Lesica 1985; Schassberger 1988).

This paper is a progress report on three studies being conducted on populations of A. fecunda in Ravalli County. The studies and their purposes are:

1. Long-term monitoring of A. fecunda populations in order to determine important life history attributes and trends in overall recruitment and mortality.

2. Spotted knapweed removal study, in order to determine the effects of knapweed competition on the performance of A. fecunda.

3. Soil crust ecology study, in order to assess the importance of soil crust to the establishment and survival of A. fecunda plants.

METHODS

Study Areas

Studies were conducted at two Arabis fecunda sites in Ravalli County, Montana: Charleys Gulch and Birch Creek. The Charleys Gulch site is on a steep, eroding, southwest-facing slope along the drainage at an elevation of ca. 1524 m. (5000 ft.) (T6N R19W S29, NW1/4). The Birch Creek site is on a steep, eroding, southeast-facing slope above the creek at an elevation of ca. 1433 m. (4700 ft). (T7N R19W S16, NW1/4). Complete descriptions of the study sites can be found in Lesica (1985) and Schassberger (1988).

Long-term Monitoring Study

In May, 1987, we established permanent belt transects of 12 adjacent 1 m^2 plots at both sites following the methods outlined in Lesica (1987). Individual A. fecunda plants were mapped and recorded using the following system:

S = seedling
R = the number of rosettes per plant
I = the total number of inflorescences (stems) per plant
F = the total number of fruits produced by the plant

Thus, a plant with two rosettes, three stems and a total of nine fruits would be recorded as R1-I3-F9. Seedlings were recognized by their small size and the absence of leaves from the previous year. In addition, we noted the presence of recently disturbed soil and evidence of livestock trampling. We did not record seedlings at the Birch Creek site in 1987. The transects were read on May 19-20, 1987 and 1988.

Knapweed Removal Study

In May, 1987, we established permanent belt transects consisting of 10 adjacent 1 m^2 plots at each of the study sites following the methods of Lesica (1987). Transects were placed in areas with relatively heavy knapweed infestations. Individual A. fecunda plants were mapped and recorded as in the long-term monitoring study. For each transect, we removed the knapweed from five randomly selected plots by carefully cutting the plants below the root crown with a sharp knife. Knapweed was removed from plots 2,4,5,8, and 9 at Birch Creek and from plots 1,4,5,8, and 9 at Charleys Gulch. We did not record seedlings at the Birch Creek site in 1987. The transects were read on May 19-20, 1987 and 1988.

Soil Crust Ecology Study

In order to determine whether there is an association between intact cryptogamic soil crust and the distribution of A. fecunda, we estimated cover of soil crust and bare ground in belt transects consisting of adjacent 1 m^2 plots. These transects were chosen to be representative of the steep, highly erodible slopes where A. fecunda is most frequent. We measured cover of bare ground and soil crust using a point-frequency frame (Mueller-Dombois and Ellenberg 1974, p. 86). The frame was 1 X 1 m with 20 equally-spaced pins. In each plot, the pins were dropped to the surface and the number of hits on bare soil and soil crust was recorded. Hits on exposed rock were not included in subsequent analyses. The diameter of the pins was approximately equal to the diameter of a taproot of A. fecunda (ca. 0.1 in). In addition, we recorded the number of A. fecunda plants rooted in the soil crust and the total number of A.

fecunda plants in each 1 m^2 plot. At Charleys Gulch, we read two transects (10 and 12 plots), and at Birch Creek, we read one transect (22 plots). All of the transects were located in areas subject to livestock grazing. Transects were read on May 19-20, 1988.

RESULTS AND DISCUSSION

Long Term Monitoring Study

A summary of the data from two years of the long-term monitoring study is presented in Table 1. At both sites the density of plants was slightly lower in 1988 than in 1987. In addition, the number and percentage of fruiting plants was appreciably lower in 1988 than in 1987. At both sites, however, the total number of fruits per fertile plant, and the number of fruits per inflorescence, was greater in 1988. These results probably indicate various stress responses to the drought conditions that began in 1987 and continued into 1988.

Size and fecundity data for individual Arabis fecunda plants over the two-year period are presented in Appendix A. These data are summarized in Table 2. It is too early in the study to determine whether these populations are stable, growing or declining; nonetheless, it is worth noting some trends. At Charleys Gulch, where only one plant was lost to apparent soil slumping, recruitment and adult mortality were approximately equal in both years. At Birch Creek, where 15 plants were lost to soil slumping, adult mortality was appreciably higher than recruitment. In most cases of soil slumping at Birch Creek, we observed hoof prints of cattle in the slumped areas. If these 15 plants had not been lost, mortality and recruitment would have been approximately equal. At Charleys Gulch, apparent seedling survival was greater than seedling mortality. However, these results have limited meaning because appreciable seedling mortality may have occurred prior to reading the transects in late May.

Knapweed Removal Study

One year after removing spotted knapweed plants from the experimental plots, its cover was approximately equal to that in the control plots (Table 3). This result can be explained in part by new recruitment of seedlings and in part by a failure to completely eradicate all plants in 1987. Nonetheless, the competitive ability of knapweed in the removal plots should have been reduced during at least part of the 1987 growing season.

Table 1. Population density and fecundity data for Arabis fecunda in long-term monitoring transects, 1987-1988.

		Birch Creek	Charleys Gulch
Density (plants/m^2)	1987	5.0	6.3
	1988	4.6	5.2
# plants fruiting	1987	17	26
	1988	7	10
% plants fruiting	1987	34%	41%
	1988	11%	14%
# fruits per fruiting plant	1987	3.8	5.7
	1988	14.0	6.3
# fruits per inflorescence	1987	2.3	2.3
	1988	5.2	4.3
% plants with more than one rosette	1987	11%	22%
	1988	7%	29%
% one-rosette plants with fruit	1987	25%	37%
	1988	13%	24%
% multi-rosette plants with fruit	1987	83%	67%
	1988	0%	13%

Table 2. Summary of size and fecundity data for individual *Arabis fecunda* plants in permanent monitoring transects, 1987-1988.

	Birch Creek	Charleys Gulch
Plants first observed in 1988	9	5
1987 plants not observed in 1988	25	7
Number of plants with a greater number of rosettes in 1988	3	3
Number of plants with a smaller number of rosettes in 1988	2	0
Plants with the same number of rosettes in 1987 and 1988	33	30
Plants with increased fecundity in 1988	3	6
Plants with decreased fecundity in 1988	10	12
Seedling survival	--	64%

Table 3. Percent canopy cover of knapweed (*Centaurea maculosa*) in removal transects in 1987 and 1988 (before knapwed removal). An asterisk (*) indicates plots from which knapweed was removed; remaining plots are controls.

Charleys Gulch #2

Year	* 1	2	3	* 4	* 5	6	7	* 8	* 9	10	Control Mean	Removal Mean
1987	20	25	20	25	28	23	20	23	30	25	23	25
1988	5	20	28	15	18	30	25	23	18	35	28	16

Birch Creek #2

Year	1	* 2	3	* 4	* 5	6	7	* 8	* 9	10	Control Mean	Removal Mean
1987	30	35	35	30	33	38	28	23	23	28	32	29
1988	30	20	30	30	20	30	15	30	30	20	25	26

Density and fecundity data for plants of A. fecunda in removal and control plots are presented in Table 4. In general, these data show the same trends as found in the long-term monitoring study: a drastic reduction in number and percent of plants fruiting and an increase in the average number of fruits per inflorescence and per fruiting plant in 1988 (see above for discussion). Density of A. fecunda plants at Charleys Gulch showed no increase in 1988 in either the control plots or the removal plots. At Birch Creek, while control plots showed no appreciable increase in density of A. fecunda plants in 1988, there was a more than three-fold increase in the removal plots. The density of A. fecunda in individual removal and control plots in 1987 and 1988 at Birch Creek are presented in Table 5. Between 1987 and 1988, density decreased slightly in all but one of the control plots, while density increased in all but one of the knapweed removal plots. Our notes from 1987 indicate that there were large numbers of seedlings in plots 8, 9, and 10. Many of these survived in the removal plots (plots 8 and 9), but few survived in the control plot (plot 10). These results suggests that A. fecunda recruitment may be curtailed by the presence of knapweed.

Soil Crust Ecology Study

In this study, the null hypothesis is that within the three belt transects Arabis fecunda plants are distributed at random, i.e., without respect to the presence of soil crusts. The results of a chi-square analysis of the data are presented in Table 6. The null hypothesis was strongly rejected in all three cases, indicating that the distribution of A. fecunda is not random. The data show that A. fecunda is associated more often with soil crusts than bare soil within the transects. There are two possible explanations for these results: (1) A. fecunda is able to establish and survive better in soil crusts, and/or (2) A. fecunda is able to establish and survive with equal success in bare soil and soil crusts; however, perturbations caused by livestock destroy not only the A. fecunda plants growing in bare soil and soil crust, but also the soil crust itself. This would result in an increase in the amount of bare soil without A. fecunda. These two explanations are not mutually exclusive.

If the first explanation is correct, A. fecunda may be dependent on the presence of soil crusts to maintain viable population levels within these transects. Grazing by livestock has been shown to reduce the cover of soil crusts (St. Clair et al. 1984), thus reducing the availability of microsites which are important for seedling establishment and survival. If the second explanation is correct, livestock grazing is destroying A. fecunda plants in these transects regardless of whether they are rooted in bare soil or soil crusts. Under either interpretation, our results indicate that livestock grazing is detrimental to populations of A. fecunda on the steep, highly erodible slopes in these transects.

Table 4. Density and fecundity data for *Arabis fecunda* in knapweed removal transects.

		Birch Creek		Charley's Gulch	
		Removal	Control	Removal	Control
Density (plants/m^2)	1987	16.0	21.4	12.8	14.2
	1988	54.6	24.0	14.2	14.6
# plants fruiting	1987	44	41	29	24
	1988	6	7	2	2
% plants fruiting	1987	55%	38%	45%	34%
	1988	2%	6%	3%	3%
# fruits per fruiting plant	1987	6.3	4.8	4.7	4.1
	1988	15.2	5.7	11.5	8.5
# fruits per inflorescence	1987	2.5	2.4	2.2	2.2
	1988	5.1	3.6	4.6	3.4
% plants with more than one rosette	1987	19%	36%	14%	25%
	1988	7%	17%	13%	29%
% one-rosette plants with fruit	1987	51%	55%	47%	28%
	1988	2%	8%	4%	2%
% multi-rosette plants with fruit	1987	73%	66%	33%	50%
	1988	10%	0%	0%	5%

Table 5. Density of Arabis fecunda plants in individual knapweed removal and control plots at the Birch Creek site in 1987 and 1988.

Control		
Plot #	1987	1988
1	23	21
3	27	25
6	11	26
7	19	18
10	27	29

Removal		
Plot #	1987	1988
2	16	20
4	22	26
5	15	13
8	16	145
9	11	69

Table 6. Density of bare soil and soil crust and the number of *Arabis fecunda* plants growing in each type of substrate in three belt transects.

Site	# point hits on soil crust	# point hits on bare soil	# of *A. fecunda* in soil crust	# of *A. fecunda* in bare soil	χ^2	p
Birch Creek	97	289	81	48	61	<0.0001
Charleys Gulch West	83	117	100	27	44	<0.0001
Charleys Gulch	78	147	52	21	30	<0.0001

CONCLUSIONS

All of the studies reported on are still in progress, and any conclusions must be considered tentative until more data has been collected. Nonetheless, several trends are apparent and are worthy of comment. Results of the long-term monitoring and soil crust ecology studies suggest that livestock grazing on the steep highly erodible slopes, where the transects were located, is destructive, and is probably detrimental to the long-term viability of Arabis fecunda populations. Results of the knapweed removal study suggest that, under certain circumstances, spotted knapweed may be inhibiting recruitment of Arabis fecunda seedlings. Thus, both livestock grazing and knapweed encroachment may pose a threat to populations of Arabis fecunda.

LITERATURE CITED

Drake, J. A. 1988. Biological invasions into nature reserves. Trends in Ecology and Evolution 3: 186-187.

Lesica, P. 1985. Report on the conservation status of Arabis fecunda, a potential candidate species. Unpublished report to the U.S. Fish and Wildlife Service, Office of Endangered Species, Denver, CO.

Lesica, P. 1987. A technique for monitoring nonrhizomatous, perennial plant species in permanent belt transects. Natural Areas Journal 7: 65-68.

Massey, J. R. and P. D. Whitson. 1980. Species biology, the key to plant preservation. Rhodora 82: 97-103.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods in vegetation ecology. John Wiley and Sons, New York.

Palmer, M. E. 1987. A critical look at rare plant monitoring in the United State. Biological Conservation 39: 113-127.

Rollins, R. C. 1984. Studies in the Cruciferae of western North America II. Contributions to the Gray Herbarium 214: 1-18.

St. Clair, L. L., B. L. Webb, J. R. Johansen and G. T. Nebeker. 1984. Cryptogamic soil crusts: Enhancement of seedling establishment in disturbed and undisturbed areas. Reclamation and Revegetation Research 3: 129-136.

Schassberger, L.A. 1988. An update of the report on the conservation status of Arabis fecunda, a candidate threatened species. Unpublished report to the U.S. Fish and Wildlife Service, Office of Endangered Species, Denver, CO.

Sutter, R. D. 1986. Monitoring rare plant species and natural areas - ensuring the protection of our investment. Natural Areas Journal 6: 3-5.

Appendix A. Performance of individual Arabis fecunda plants in permanent monitoring transects in 1987 and 1988. Seedlings were not recorded at Birch Creek in 1987. An asterisk (*) indicates a plant lost due to slumping soil.

Birch Creek

Plot #	1987	1988
1.	R1	R1
	R1	R1
	R3	R4
	R2-I3-F6	R2
2.	R1	--*
	R1	--*
	R1	--*
	R1	--*
	R1	--*
	R1	R1
	R1-I1-F3	--
	R1	R1
	R1	R1
	R1	R1
	R1-I2-F3	--*
3.	R1-I1-F1	--*
	R1-I2-F4	--*
	R1	--*
4.	R2	--*
	R1	R1
	--	R1
	R1	R1
	--	R1
5.	R1	--
	R1	R1
	R1	R1
	R2-I1-F6	R1
	R1	R1
	R1	R1
	R1	--
6.	R1	R2
	R1	R1
	--	R1
	R1-I2-F6	R1
	R1-I1-F3	R1-I3-F9
	R2-I2-F5	R1
	R1	R1
	--	R1
	R1	R1-I2-F12

7.	R1-I1-F3	R1
	R1	--
	R1-I2-F2	R1
	R1	--
8.	R1-I1-F3	R3
	R1	R1
	R1-I2-F4	R1
	R1	R1
	R1	R1
9.	R2-I2-F5	--*
	R1-I3-F6	--*
	R1-I1-F5	--*
	R1	--*
	R2-I1-F2	--*
10.	--	S
	--	S
11.	R1	R1
	R1	--
	R1	--
	R1	R1
	R1	R1-I1-F3
	--	R1
	--	R1
	--	R1
12.	R1-I3-F7	R1
	R1	R1
	R1	--
	R1	R1
	R1-I1-F1	--
	R1	R1
	R1-I2-F3	R1
	R1	--
	R1	R1
	--	R1
	--	S
	--	S
	--	S
	--	R1
	--	R1
13.	NOT RECORDED	R1
		R1
		R1-I1-F5
		R1
		R1
		R1-I5-F22

14.	NOT RECORDED	R1-I5-F34 R1 R1 R1 R1-I2-F13

Charleys Gulch

1.	S R1-I1-F2 S S R1-I4-F15	R1 R1-I1-F3 R2 R1 R1-I5-F23
2.	S	R1-I1-F6
3.	NO PLANTS	
4.	R1-I3-F5 R2-I4-F11	R1 R2-I1-F5
5.	S R1-I5-F15	-- R1-I2-F5
6.	S R1-I1-F4 R1-I5-F13 -- -- -- -- S	-- R1-I1-F5 R1-I2-F12 R2 S S S R1
7.	R1-I5-F11 R1-I1-F2 R1-I1-F2 S S R1-I3-F1	R1-I13-F17 R2 --* S R2 R1-I4-F17
8.	NO PLANTS	
9.	NO PLANTS	
10.	R2 R1-I3-F6 R1 R1 R2-I2-F5 S S R1-I6-F0	R2 R1 R1 R1 R2 -- -- --

11.	R3-I4-F8	R3
	R1-I1-F2	R1
	R1-I1-F1	R1
	R3	--
	R1	R1
	R1	R1
	R1	R1
	R2	R2
	R3-I3-F5	R3
12.	R2-I1-F4	--
	R1-I1-F2	R1
	R1-I1-F2	R1
	R2	R2
	--	S

VI. SLIDES OF MONITORING TRANSECTS AND LOCATIONS